Finite-Size Effects in Periodic Silver Nanosphere Arrays Revealed using Electron Energy-Loss Spectroscopy (EELS) Modeling.

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Electron energy-loss spectroscopy (EELS) provides a unique approach when probing plasmonic nanostructures since it can locally excite and probe specific localized surface plasmon (LSP) modes. Contrary to optical spectroscopy, EELS is also able to excite and probe optically-dark modes such as the bulk plasmon and high order LSPs that do not have a net electric dipole moment. An additional strength of EELS over optical spectroscopy is its ability to single out and investigate specific individual modes due to its local-excitation nature. Yet, to the best of our knowledge, only one early theoretical work by Garcia de Abajo [2] has explored the possibility of using EELS to study periodic nanostructures. Here, we investigate the plasmonic properties of 2-dimensional finite nanosphere arrays using the boundary element method (BEM) to solve the integral form of Maxwell's equations in the context of EELS. We performed a systematic study of silver nanosphere arrays while varying key parameters such as array dimensions and electron beam impact coordinate. We compare these EELS spectra to optical calculations, also performed with the boundary element method (BEM), in order to single out the finite-size and edge effects of such periodic nanostructures. By exploring these key parameters and comparing them to optical calculations, we gained a deeper understanding of the plasmonic properties of these metasurfaces. In particular we show that, contrary to theoretical previous studies revealing that arrays containing 15x15 nanoparticles exhibit the same optical properties as infinite arrays, plasmon modes sustained by these arrays experience the presence of the array edges. These subtle effects, revealed when probing specific region of the array with electron beam excitations, are of great importance for the realization of high precision sensors and imaging platforms.

Reference:

[1] Cao, Y.; Manjavacas, A.; Large, N. & Nordlander, P. "Electron Energy-Loss Spectroscopy Calculation in Finite-Difference Time-Domain Package." *ACS Photonics,* **2015**, *2*, 369-375

[2] García de Abajo, F. J. & Blanco, L. A. "Electron energy loss and induced photon emission in photonic crystals." *Phys. Rev. B*, **2003**, *67*, 125108-125108